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(54) **AUTHENTICATION AND PAIRING OF A MOBILE DEVICE TO AN EXTERNAL POWER SOURCE**

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(51) **Int. Cl.**

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G06Q 30/04	(2012.01)
B60L 11/18	(2006.01)
G06F 21/81	(2013.01)
G06F 21/84	(2013.01)
G06Q 50/06	(2012.01)

(52) **U.S. Cl.**

CPC ***G06Q 30/04*** (2013.01); ***B60L 11/1809*** (2013.01); ***B60L 11/1838*** (2013.01); ***B60L 11/1846*** (2013.01); ***G06F 1/26*** (2013.01); ***G06F 21/81*** (2013.01); ***G06F 21/84*** (2013.01); ***G06Q 50/06*** (2013.01); *G06F 2221/0704* (2013.01); *Y02T 10/7005* (2013.01); *Y02T 10/7094* (2013.01); *Y02T 90/121* (2013.01); *Y02T 90/128* (2013.01); *Y02T 90/14* (2013.01); *Y02T 90/16* (2013.01); *Y02T 90/163* (2013.01); *Y02T 90/169* (2013.01); *Y04S 30/14* (2013.01)

(58) **Field of Classification Search**

CPC G06F 1/26; G06F 1/266; G06F 1/28; B60L 11/1809; B60L 11/1824; B60L 11/1838; B60L 11/1846; B60L 11/1848

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

8,990,593	B2 *	3/2015	Marlin et al.	713/300
2010/0145568	A1	6/2010	Watanabe	
2010/0274697	A1	10/2010	Zyren	
2011/0191265	A1	8/2011	Lowenthal et al.	
2012/0074903	A1	3/2012	Nakashima	
2013/0119947	A1	5/2013	Ishida et al.	

* cited by examiner

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(57) **ABSTRACT**

A mobile device communicates with an authenticator affiliated with a recharging facility, to identify itself. To confirm that the mobile device is connected to the correct facility, the authenticator instructs the mobile device to draw electrical charge according to an identifiable pattern. Upon detecting a charge being drawn according to that pattern, the authenticator has confirmation that the identified device is connected to the facility, and permits the charging to proceed. The amount of electricity drawn during the charging procedure can be metered, and then billed to a party associated with the identified mobile device.

32 Claims, 6 Drawing Sheets

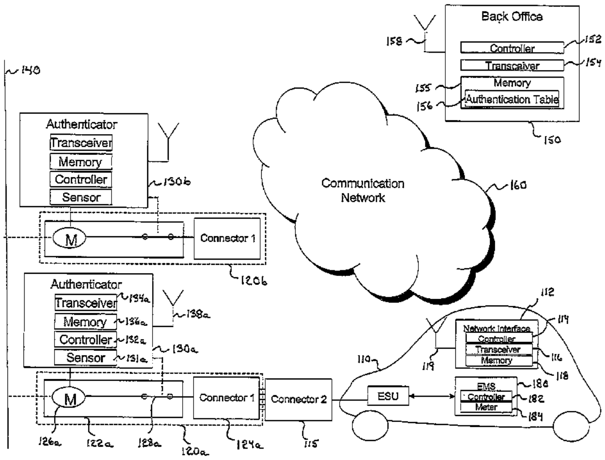
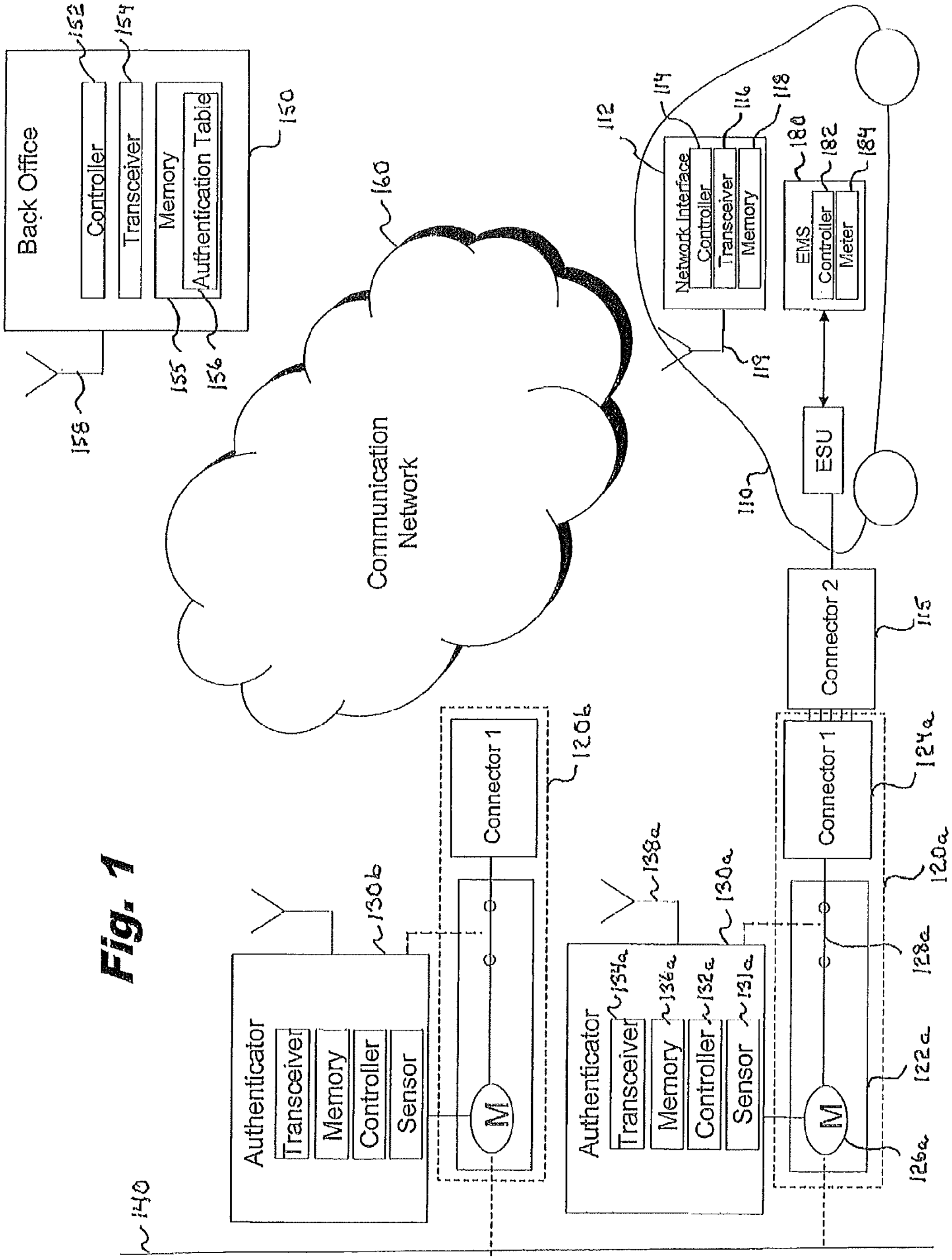


Fig. 1


Back Office
Controller
Transceiver
Memory
Authentication Table
150
152
154
155
156
158
Communication Network
160
Network Interface
Controller
Transceiver
Memory
112
114
116
118
119
EMS
Controller
Meter
180
182
184
ESU
110
Connector 2
115
Connector 1
124a
120a
Connector 1
120b
Authenticator
Transceiver
Memory
Controller
Sensor
130b
Authenticator
Transceiver
Memory
Controller
Sensor
130a
134a
136a
132a
131a
138a
128a
122a
126a
M
M
140

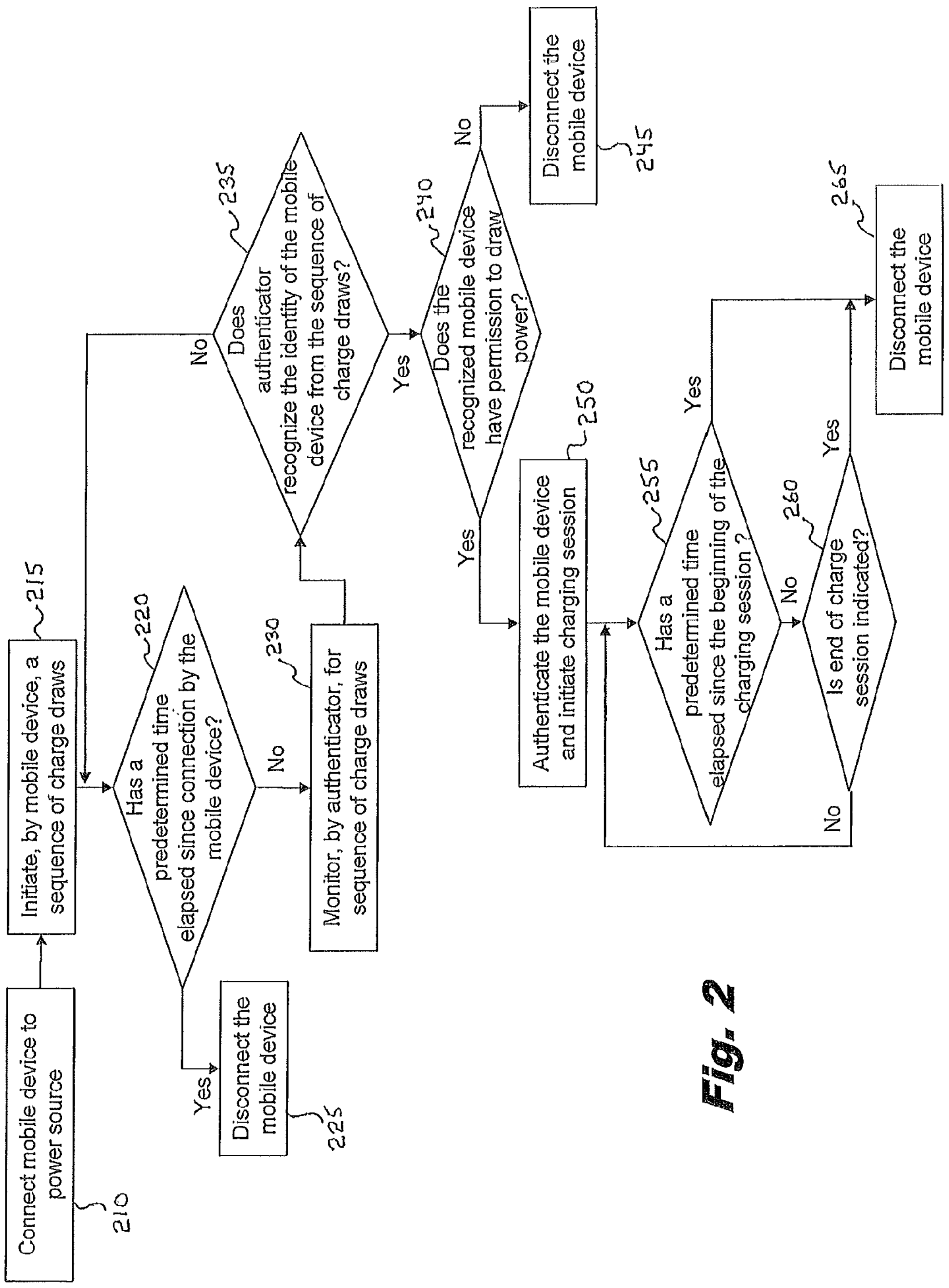
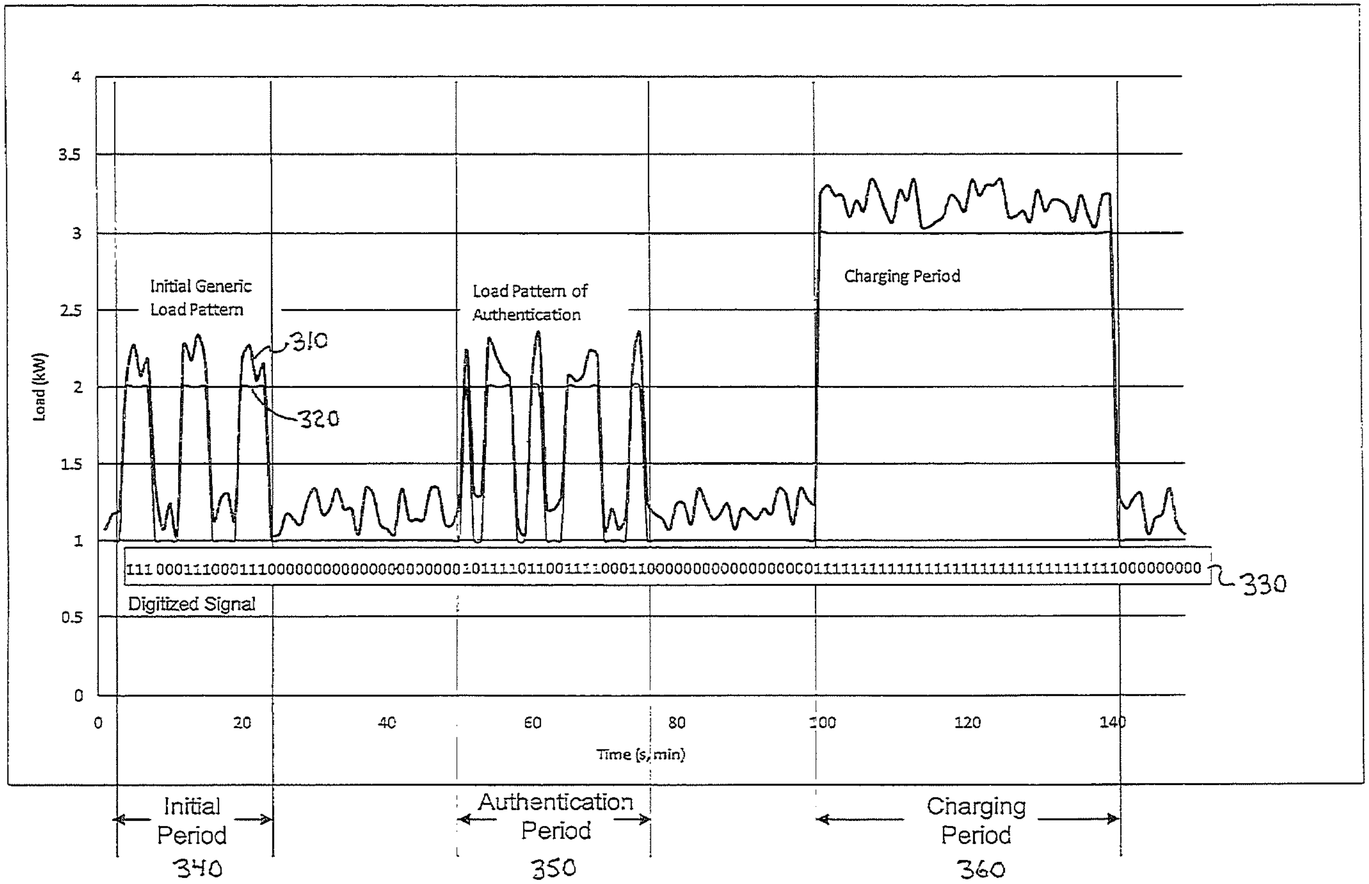

Connect mobile device to power source
210
Initiate, by mobile device, a sequence of charge draws
215
Has a predetermined time elapsed since connection by the mobile device?
220
Yes
Disconnect the mobile device
225
No
Monitor, by authenticator, for sequence of charge draws
230
Does authenticator recognize the identity of the mobile device from the sequence of charge draws?
235
No
Yes
Does the recognized mobile device have permission to draw power?
240
No
Disconnect the mobile device
245
Yes
Authenticate the mobile device and initiate charging session
250
Has a predetermined time elapsed since the beginning of the charging session ?
255
Yes
No
Is end of charge session indicated?
260
Yes
No
Disconnect the mobile device
265

Fig. 2

Fig. 3



4
3.5
3
2.5
2
1.5
1
0.5
0
Load (kW)
0
20
40
60
80
100
120
140
Time (s, min)
Initial Generic Load Pattern
Load Pattern of Authentication
Charging Period
310
320
111 0001110001110000000000000000000000000101111011001110001100000000000000000000C0111111111111111111111111111111111111111111000000000
330
Digitized Signal
Initial Period 340
Authentication Period 350
Charging Period 360

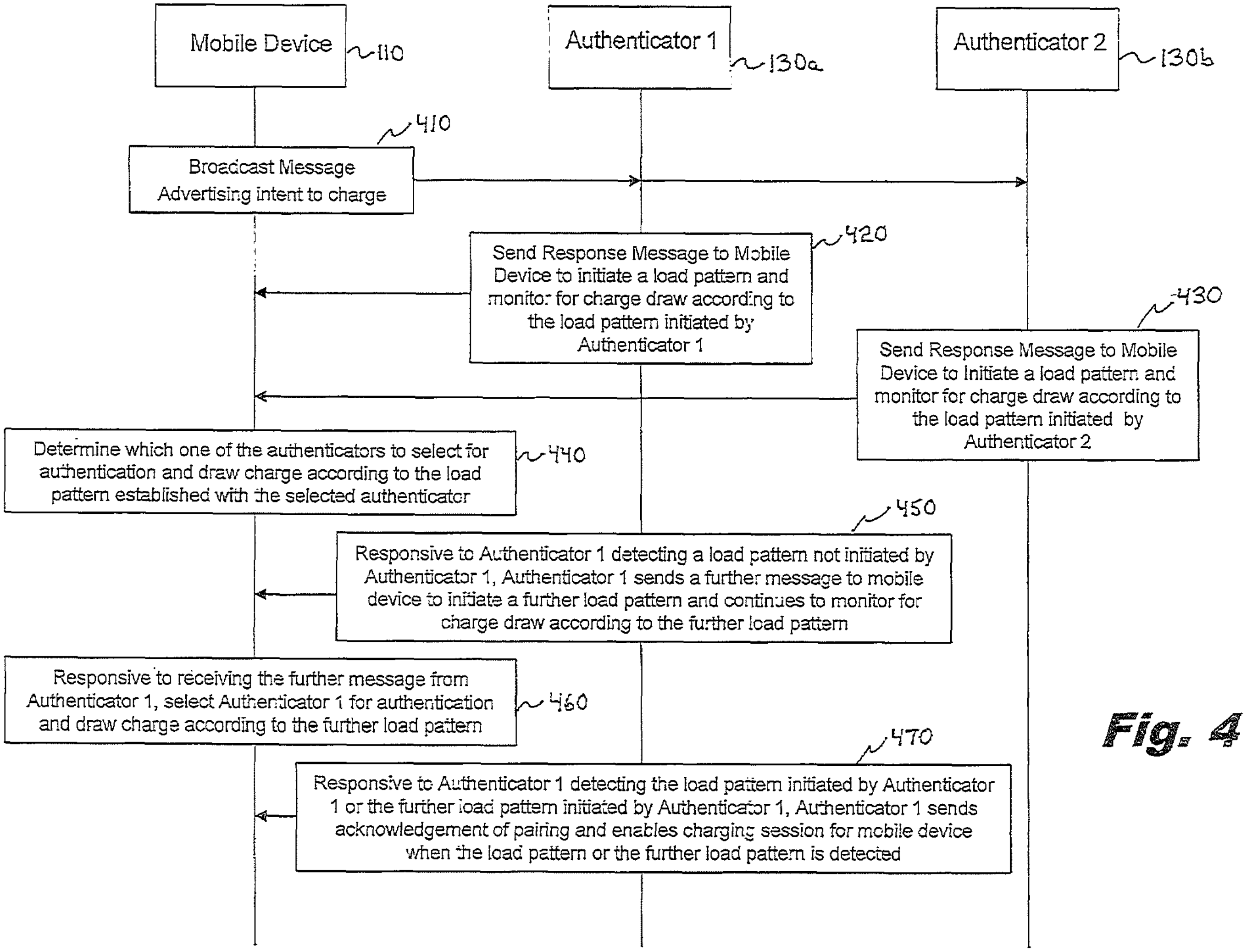

Mobile Device
110
Authenticator 1
130a
Authenticator 2
130b
410
Broadcast Message
Advertising intent to charge
420
Send Response Message to Mobile Device to initiate a load pattern and monitor for charge draw according to the load pattern initiated by Authenticator 1
430
Send Response Message to Mobile Device to Initiate a load pattern and monitor for charge draw according to the load pattern initiated by Authenticator 2
Determine which one of the authenticators to select for authentication and draw charge according to the load pattern established with the selected authenticator
440
450
Responsive to Authenticator 1 detecting a load pattern not initiated by Authenticator 1, Authenticator 1 sends a further message to mobile device to initiate a further load pattern and continues to monitor for charge draw according to the further load pattern
Responsive to receiving the further message from Authenticator 1, select Authenticator 1 for authentication and draw charge according to the further load pattern
460
470
Responsive to Authenticator 1 detecting the load pattern initiated by Authenticator 1 or the further load pattern initiated by Authenticator 1, Authenticator 1 sends acknowledgement of pairing and enables charging session for mobile device when the load pattern or the further load pattern is detected

Fig. 4

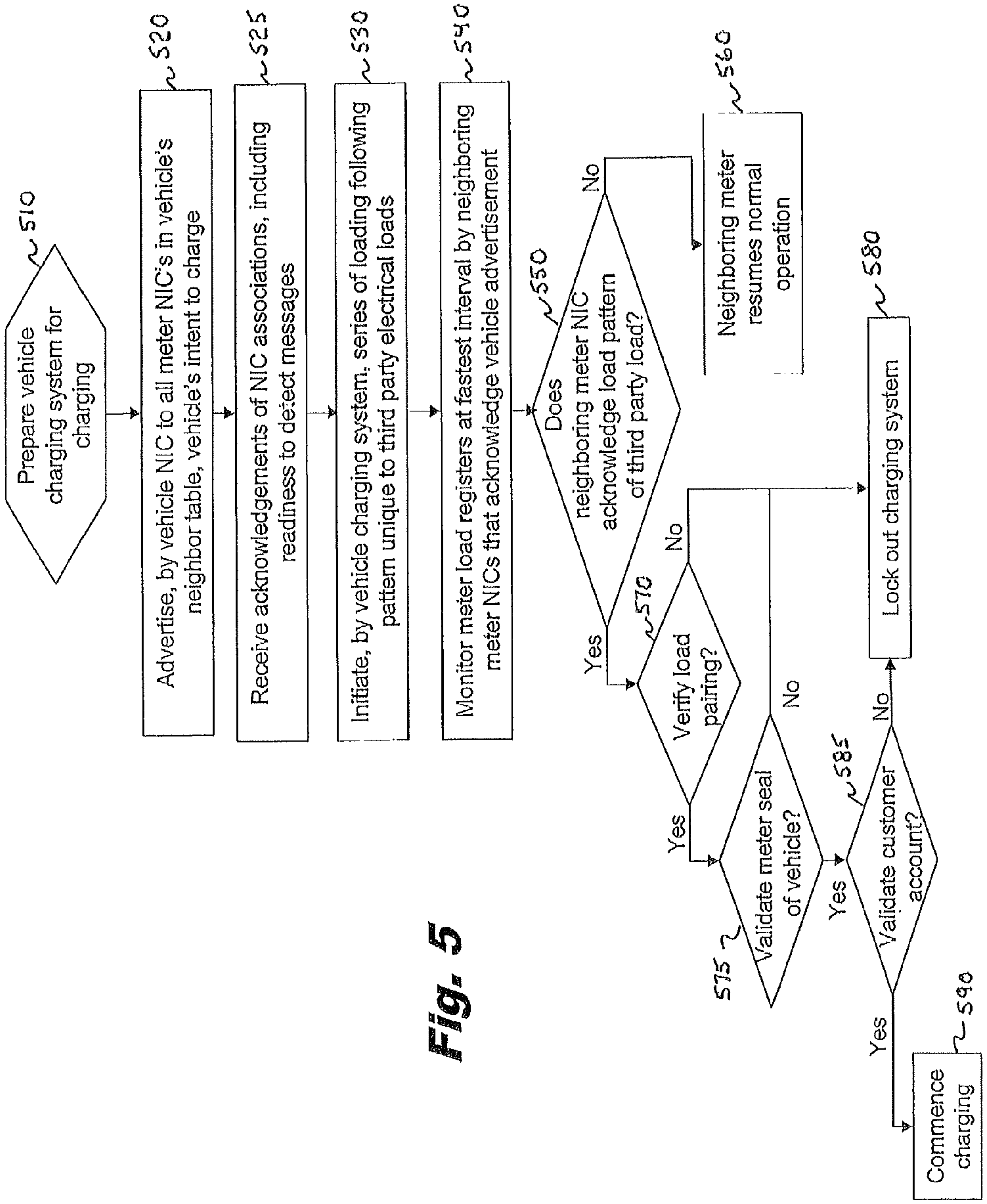

510
Prepare vehicle charging system for charging
520
Advertise, by vehicle NIC to all meter NIC's in vehicle's neighbor table, vehicle's intent to charge
525
Receive acknowledgements of NIC associations, including readiness to detect messages
530
Initiate, by vehicle charging system, series of loading following pattern unique to third party electrical loads
540
Monitor meter load registers at fastest interval by neighboring meter NICs that acknowledge vehicle advertisement
550
Does neighboring meter NIC acknowledge load pattern of third party load?
No
560
Neighboring meter resumes normal operation
Yes
570
Verify load pairing?
No
Yes
575
Validate meter seal of vehicle?
No
Yes
585
Validate customer account?
No
580
Lock out charging system
Yes
590
Commence charging

Fig. 5

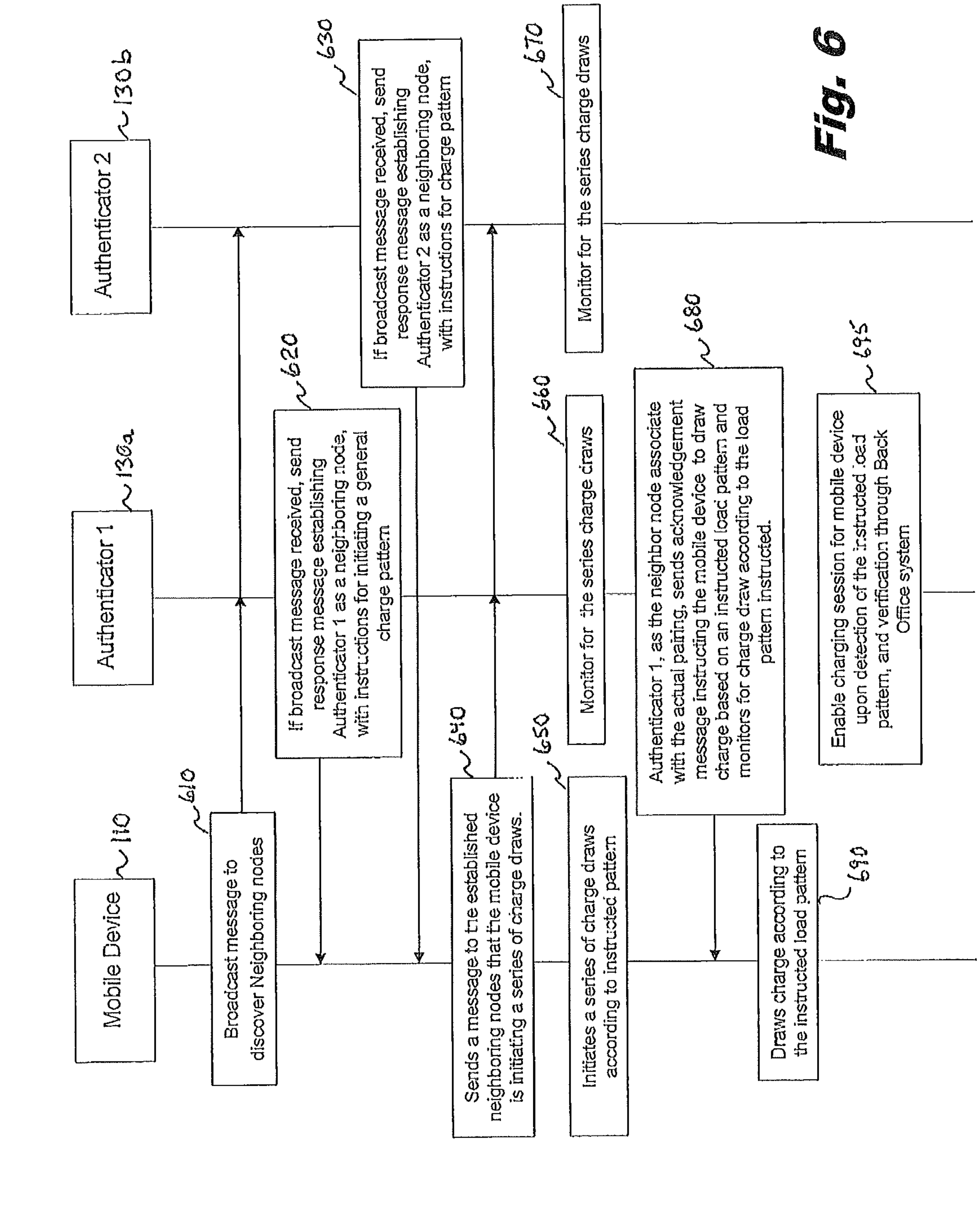

Mobile Device
110
Authenticator 1
130a
Authenticator 2
130b
Broadcast message to discover Neighboring nodes
610
If broadcast message received, send response message establishing Authenticator 1 as a neighboring node, with instructions for initiating a general charge pattern
620
If broadcast message received, send response message establishing Authenticator 2 as a neighboring node, with instructions for charge pattern
630
Sends a message to the established neighboring nodes that the mobile device is initiating a series of charge draws.
640
Initiates a series of charge draws according to instructed pattern
650
Monitor for the series charge draws
660
Monitor for the series charge draws
670
Authenticator 1, as the neighbor node associate with the actual pairing, sends acknowledgement message instructing the mobile device to draw charge based on an instructed load pattern and monitors for charge draw according to the load pattern instructed.
680
Draws charge according to the instructed load pattern
690
Enable charging session for mobile device upon detection of the instructed load pattern, and verification through Back Office system
695

Fig. 6

AUTHENTICATION AND PAIRING OF A MOBILE DEVICE TO AN EXTERNAL POWER SOURCE

RELATED APPLICATION

This application is a continuation application of application Ser. No. 13/362,416, filed Jan. 31, 2012. The entire content of this application is hereby incorporated by reference in its entirety.

FIELD OF THE INVENTION

The present disclosure relates generally to systems and methods for authentication of mobile devices and, more particularly, to the authentication of a mobile electric device using a charging pattern of the mobile device.

BACKGROUND OF THE INVENTION

Many different electronic and mechanical devices include battery storage, which are connected to the electric utility grid for recharge. Generally, costs for the energy used to recharge such mobile devices are assessed to the owner or provider of the outlet used for charging the mobile device, and are billed based on meter reading at the owner's meter associated with the outlet used for charging.

SUMMARY OF THE DISCLOSURE

In accordance with embodiments disclosed herein, the cost associated with the recharging of a mobile device can be allocated to the owner of the device, rather than the premises where the outlet is located, through a procedure for authenticating the device owner at the time of recharging the device. The mobile device communicates with an authenticator affiliated with the recharging facility, to identify itself. To confirm that the mobile device is connected to the correct facility, the mobile device draws a charge according to a pattern that is recognized by the authenticator. Upon detecting a charge being drawn according to that pattern, the authenticator has confirmation that an identified device is connected to the facility, and permits the recharging to proceed. The amount of electricity drawn during the recharging procedure can be metered, or otherwise determined and then billed to a party associated with the identified mobile device.

BRIEF DESCRIPTION OF THE DRAWING FIGURES

The invention is best understood from the following detailed description when read in conjunction with the accompanying drawings. It is emphasized that, according to common practice, the various features of the drawings are not to scale. On the contrary, the dimensions of the various features are arbitrarily expanded or reduced for clarity. Included in the drawings are the following figures:

FIG. **1** is a schematic diagram illustrating a system for authenticating a pairing of a power source and mobile device in accordance with an exemplary embodiment of the present invention;

FIG. **2** is a flowchart illustrating a method of authentication of a mobile device in accordance with a first exemplary embodiment;

FIG. **3** is a graph illustrating a load pattern used in systems and methods in accordance with exemplary embodiments of the present invention;

FIG. **4** is a timing diagram illustrating communications between or among a mobile device and authenticators in accordance with a second exemplary embodiment;

FIG. **5** is a flowchart illustrating a method of managing a charging session in accordance with the second exemplary embodiment;

FIG. **6** is timing diagram illustrating communications between or among a mobile device and authenticators in accordance with a third exemplary embodiment.

DETAILED DESCRIPTION OF THE INVENTION

Mobile electric devices such as plug-in electric cars, laptop computers, notebook computers, PDAs, and cell phones, among others, are proliferating with the advent of a more mobile society. The ability to recharge such devices may be limited to electrical outlets associated with an owner of the mobile electric devices (e.g., where the billing account associated with electrical outlet and the owner of the mobile device are the same entity) or where the billing account owner associated with the electrical outlet allows the owner of the mobile device to recharge the mobile device at no charge. The owner associated with an electrical outlet generally refers to the individual or entity who is financially obligated to pay for the electricity consumed at the electrical outlet, which may include the owner of the electrical outlet or a third party responsible for such payments.

In various exemplary embodiments, a mobile electronic device may be authenticated to the electrical outlet, power connection or power source used for charging. By authenticating to such an outlet, power connection or power source, the billing account associated with the mobile device may be billed for the cost of recharging of the mobile device.

In certain exemplary embodiments, an authenticator may negotiate or specify a load pattern used by the mobile electronic device to identify its pairing with the electrical outlet, the power source or the power connection.

To facilitate an understanding of the concepts that underlie the invention, exemplary embodiments are described in which the mobile device is a plug-in electric vehicle. It will be appreciated, however, that the mobile electric device may be any device which is mobile and capable of recharge from any power source such as the electric grid, a generator, or another mobile device, among others.

FIG. **1** is a schematic diagram illustrating a system **100** for authenticating a pairing of a power source **122***a* and mobile electrical device **110** in accordance with exemplary embodiments disclosed herein. Referring thereto, system **100** may include mobile electric device **110**, first electric supply site **120***a*, second electric supply site **120***b*, first authenticator **130***a*, second authenticator **130***b* and electric grid **140**. The apparatus and functions associated with first electric supply site **120***a* are substantially the same as those of second electric supply site **120***b*.

First electric supply site **120***a* may include first power source **122***a* and first connector **124***a*. First electric power source **122***a* may be connected to utility grid **140** for supply of electric power to first connector **124***a*, or may be a stand alone power source for generating electrical power.

Although first electric power supply **122***a* is shown connected to electric grid **140**, it is contemplated that any power source may be used, including both alternating current (AC) and direct current (DC) power sources such as batteries, fuel cells, photovoltaics, and electric generators, among others. First electric power source **122***a* may include a meter/sensor **126***a* and a load switch **128***a*.

Meter/sensor **126***a* may measure current draw through first electric power source **122***a*. Meter sensor **126***a* may be coupled to first authenticator **130***a*. First authenticator **130***a* may be located at the first electric supply site or may be located remotely, for example, in a vicinity of a plurality of electric metering sites or in the vicinity of back office **150**.

Although first authenticator **130***a* is shown coupled to meter/sensor **122***a*, it is contemplated that first authenticator **130***a* may be coupled to any number of meters/sensors to measure the charge (e.g., current) drawn at a plurality of electric meter sites for authentication of the electrical outlets, power sources or power connections with mobile devices. In certain exemplary embodiments, one authenticator may measure charge drawn from electric meter sites associated with a specified geographic area (e.g., a parking lot, a plurality of parking spots, or a recharging center, among others). In other exemplary embodiments, such an authenticator may be associated with or located at back office **150** and may measure charge draw associated with electric meter sites associated with back office **150**.

Load switch **128***a* may be controlled by first authenticator **130***a* to connect or disconnect electric utility grid **140** or power source **120***a* from mobile device **110**. Although load switch **128***a* is shown to connect or disconnect power entirely to/from mobile device **110**, it is contemplated that load switch **128***a* may only connect or disconnect a portion of the load of mobile device **110** (e.g., charging circuits of mobile device **110**) from power source **122***a* or electric utility grid **140**. For example, electric meter site **120***a* may continue to enable power supply to mobile device **110** for functions such as communications with first authenticator **130***a* and other processing functions of mobile device **110** using a low power connection via first connector **124***a*.

Although load switch **128***a* is shown as a single-pole single-throw switching device, it is contemplated that load switch **128***a* may include other configurations to connect or disconnect other connections including, for example a ground connection, a communications connection, and/or a presence detection circuit, among others.

First authenticator **130***a* may include a current sensor **131***a*, a controller **132***a*, a transceiver **134***a*, a memory **136***a* and an antenna **138***a*. Mobile device **110** may include a network interface **112** having a controller **114**, transceiver **116**, memory **118**, and antenna **119**. Controller **132***a* and controller **114** may establish a communication session (e.g., an internet protocol (IP) session) via transceiver **134***a* and antenna **138***a* of first authenticator **130***a* and transceiver **116** and antenna **119** of network interface **112**. Controller **132***a* may receive information (including measurements, meter readings and/or sensor readings, among others) from meter/sensor **126***a* of first electric metering site **120***a*. First connector **124***a* of first electric metering site **120***a* may connect to connector **115** of mobile device **110** to electrically connect power source **122***a* and/or utility grid **140** to mobile device **110**.

Although a converter is not shown in FIG. **1**, mobile device **110** may include a converter to convert AC power to DC power. It is also contemplated that such a converter may be disposed between utility grid **140** and mobile device **110**.

System **100** may include back office **150** in communication with a plurality of authenticators (e.g., first and second authenticators **130***a* and **130***b*) via communication network **160**. Back office **150** may include a controller **152**, a transceiver **154**, and a memory **155** (e.g., including authentication tables **156**). Controller **152** may control the operation of back office **150**. Transceiver **154** may receive and send information via communication network **160** to first and/or second authenticators **130***a* and **130***b*. Memory **155** may include data structures used to uniquely identify load patterns monitored by first or second authenticator **130***a* or **130***b* with a mobile device identifier. Authentication tables **156** may include account and billing information associated with mobile devices in system **100**.

In one embodiment, authentication tables **150** may include records having unique identifiers associated with each mobile device. When mobile device **110** connects to first electric metering site **120***a* via first connector **124***a*, first authenticator **130***a* may monitor for a current draw at first connector **124***a*. The current draw may have a unique load pattern that identifies mobile device **110**. For example, network interface **112** may have a media access control (MAC) address (e.g., a unique address) that is associated with network interface **112**. The MAC address may be encoded as a unique load pattern associated with mobile device **110**.

In an alternate embodiment, rather than employ a public address or the like as the identifier of the mobile device, a secure value, such as a secret key, that is stored at both the authenticator and the mobile device can be employed as the unique identifier of the mobile device. Furthermore, the same identification credentials can be employed by a group of users. For instance, all of the members of a family who charge to the same billing account can share the secret key, and use it to identify their mobile devices to the authenticator. In a similar manner, a group address or other such form of shared credential can be employed to identify, and authenticate, all of the members of a group.

First authenticator **130***a* may monitor for the unique load pattern of mobile device **110** and may authenticate the pairing of mobile device **110** with the first electric metering site **120***a* (and/or first power source **122***a*) in response to the unique load pattern being detected. First authenticator **130***a* may continuously monitor first electric metering site **120***a* via meter/sensor **126***a* to determine current draw from connector **124***a*. First authenticator **130***a* may determine the start of a unique load pattern based on current draw at first connector **124***a* which is below a threshold level for a specified period of time (e.g., for greater than one minute) followed by a series of loads (the load pattern) which exceeds the threshold level during at least a portion of an authentication period.

First authenticator **130***a* may determine an end to the unique load pattern based on the same or similar criteria as the start of the unique load pattern. That is, during the unique load pattern, load may exceed a threshold level to generate a sequence of load values above and below a load reference value, which will dynamically change based on at least a unique identifier of mobile device **110** (e.g., based on a MAC address, a unique identifier, or some other predetermined unique identifier of mobile device **110** and associated with network interface **112**). First authenticator **130***a* may request validation from back office **150** using authentication tables **156** to validate the unique load pattern of mobile device **110**. For example, controller **132***a* may convert the unique load pattern detected from meter/sensor **126***a* to a digital code and may request validation of the converted code from back office **150**.

Back office **150** may validate the converted code from first authenticator **130***a* and may provide a message indicating the authentication of mobile device **110**. Controller **132***a* of first authenticator **130***a*, upon receiving the message authenticating mobile device **110**, may control load switch **128***a* to maintain a connection between power source **122***a* and mobile device **110**.

In certain exemplary embodiments, first authenticator **130***a* may include memory **135***a* for storing program code executable by controller **132***a* and for storing information sent from authentication tables **156** for local authentication. For example, once mobile device **110** is authenticated (e.g., paired) with first electric metering site **120***a*, authentication information associated with mobile device **110** (e.g., the unique load pattern of mobile device **110**) and an identifier included in authentication tables **156** to identify mobile device **110** may be stored locally in memory **135***a* of first authenticator **130***a*, such that first authenticator **130***a* may authenticate the same mobile device in a subsequent authentication process (without back office **150**) based on rules established by back office **150** (e.g., when the planned current draw by mobile device **110** is below a threshold, when mobile device is of a certain type (e.g., a laptop, a PDA, a cell phone, or a plug-in vehicle) or may be set as a flag in memory **135***a* from back office **150** based on criteria set by back office **150**).

Mobile device may include an energy storage unit **170** and a energy management device **180**. Energy management device **180** may include a controller **182** and a metering unit **184**. Controller **182** of energy management device **180** may control charging and discharging of energy storage unit **170** to power, for example, mobile device **110**.

In certain exemplary embodiments, the energy management device **180** may be integral to a vehicle management system. In other exemplary embodiments, the energy management device **180** may be separate from and in communications with the vehicle management system.

FIG. **2** is a flowchart of the pairing authentication in accordance with the first embodiment. At step **210**, mobile device **110** is connected to a power source (e.g., first electric metering site **120***a*). At step **215**, mobile device **110** may initiate a sequence of charge draws. At step **220**, first authenticator **130***a* may determine whether a predetermined time has elapsed since the connection of mobile device **110** to first electric metering site **120***a*. At step **225**, responsive to the predetermined time being exceeded, mobile device **110** may be disconnected from first electric metering site **120***a* via load switch **122***a*. At step **230**, responsive to the predetermined time not being exceeded, first authenticator **130***a* may monitor for the sequence of charge draws. At step **235**, first authenticator **130***a* may determine whether the identity of mobile device **110** is recognizable from the sequence of charge draws. For example, first authenticator **130***a* may match the sequence of charge draws with a unique identifier of mobile device **110**. In certain exemplary embodiments, the unique identifier of mobile device **110** may be stored in authentication tables **158** of back office **150**. In such exemplary embodiments, first authenticator **130***a* may request via communication network **160** authentication information stored in authentication tables **158**. The request for authentication information may be sent via transceiver **134***a* of first authenticator **130***a*, communication network **160** and transceiver **154** of back office **150**. In alternate exemplary embodiments, first authenticator **130***a* may include authentication tables (not shown) for authentication locally (without communication with back office **150**).

In other alternative exemplary embodiments, first authenticator **130***a* may send a logical series of bits corresponding to the sequence of charge draws to back office **150** via communication network **160** and back office **150** may determine and direct first authenticator **130***a* regarding the recognition of the identity of the mobile device from the sequence of charge draws. Responsive to the first authenticator **130***a* and/or back office **150** not recognizing the identity of the mobile device from the sequence of charge draws, processing is sent to step **220** to determine whether a predetermined amount of time has elapsed since connection by mobile device **110**. If the predetermined amount of time has elapsed, the mobile device is disconnected at step **225**, to thereby prevent a rogue device from continuing to draw current via the authentication process.

Responsive to first authenticator **130***a* and/or back office **150** recognizing the identity of the mobile device from the sequence of charge draws, back office **150** may validate at step **240** whether the recognized mobile device has permission to draw power. For example, back office **150** may correlate the recognized identity of mobile device **110** with a billing account and it may determine, based on billing activity, payment terms, arrearages, among others, whether to permit the draw of power. If the back office does not permit the draw of power, back office **150** may send a message to first authenticator **130***a* to block a charging session. For example, first authenticator **130***a* may control load switch **128***a* to disconnect mobile device **110**, at step **245**. At step **250**, responsive to the recognized mobile device having permission to draw power, the first authenticator **130***a* may authenticate mobile device **110** and initiate a charge session. At step **255**, first authenticator **130***a* may determine whether a predetermined time has elapsed since the beginning of the charge session. Responsive to the predetermined time having elapsed, mobile device **110** may be disconnected from first electric metering site **120***a* using load switch **128***a*. Responsive to the predetermined time not having elapsed, first authenticator **130***a* may monitor for an indication that the charge session has ended. For example, first authenticator **130***a* may monitor for a current draw below a threshold level for a specified period to indicate the end of a charge session.

If the end of a charge session is indicated, first authenticator **130***a* may control load switch **128***a* to disconnect mobile device **110** at step **265**. If the end of a charging session is not indicated by the monitored charge draw, at step **260**, processing is transferred to step **255** to determine if a predetermined time has elapsed since the beginning of the charge session.

FIG. **3** is a graph of one example of a possible load pattern. The graph includes load history **310** and filtered data **320** which corresponds to load history data with high frequency components (e.g., components above a threshold frequency) removed. The load history represents a series of load patterns provided by mobile device **110**. Prior to sending its unique identification, the mobile device may first draw current according to a generic pattern that indicates an intent to draw power, during an initial period **340**. The load pattern during the initial period **340** may indicate that mobile device **110** is connected to the utility grid via first electrical metering site **120***a*, and alerts the authenticator **130***a* to begin looking for a load pattern that indicates a unique identifier. Thereafter, the mobile device **110** sends its identifier during an authentication period **350**. The load pattern associated with mobile device **110** presents a binary pattern **330** that is derived from filtered data **320**.

In response to detection and authentication of a specified load pattern, the first authenticator **120***a* may enable the initiation of a charging period **360**. If a valid load pattern is not detected, the first authenticator **120***a* may control the load switch **128***a* to open and disconnect the mobile device from the external power source. That is, the first authenticator **120***a* blocks charging of the mobile device **110**.

In one implementation of the first embodiment, the unique identifier of the mobile device may be a secret that is shared between the mobile device and the authenticator, rather than being transmitted in the clear. For example, each of the authenticator and the mobile device may store an algorithm that is seeded by the identifier of the mobile device and an identifier of the authenticator, such as its MAC address. When the mobile device initiates the generic load pattern during the initial period **340**, the authenticator can respond with its identifier, by varying any parameter of the power that is capable of being detected by the mobile device. For instance, the authenticator may cause the power source **122***a* to vary the voltage, phase or current of the power, or simply turn the power on and off, so as to encode the identifier in the power received via the connectors **115** and **124***a*. In response to receiving this identifier, the mobile device can execute the algorithm, using the received identifier and its own unique identifier as inputs, to obtain a result value. This result value is sent to the authenticator during the authentication period. Applying an inverse of the algorithm to the received result value, the authenticator can then derive the unique identifier of the mobile device. This derived identifier can then be checked against the table of authorized identifiers to authenticate the mobile device.

In the first embodiment described above, the communication between the mobile device and the authenticator are carried out via the power line connection, through current draws or other forms of modulation of the power delivered to the mobile device. In a second embodiment described hereinafter, wireless RF communication can be employed to transmit at least some of the information that is exchanged between the mobile device and one or more authenticators.

Now referring to FIG. **4**, at step **410**, when the mobile device **110** is plugged into a power outlet, it may broadcast a message to authenticators within operational range (e.g., authenticators **130***a* and **130***b*) via the network interface **112** and antenna **119**. The broadcast message may advertise an intent for mobile device **110** to charge. First authenticator **130***a* and second authenticator **130***b* may each send a response message to mobile device **110** to initiate a load pattern, at steps **420** and **430**, respectively. The load pattern may be specific to each authenticator, and/or a time stamp. Alternatively, the pattern may be specific to mobile device **110**, a fixed pattern, or portions of the load pattern may be a combination thereof. In certain exemplary embodiments, the load pattern may be based on a unique identifier of the mobile device **110** and may be obscured by hashing the unique identifier with a hash algorithm.

Responsive to receiving one or more response messages from first authenticator **130***a* and second authenticator **130***b*, at step **440** mobile device **110** may determine which one of the authenticators in its operational range (e.g., first authenticator **130***a* or second authenticator **130***b*) to select for authentication. The selection of authenticator **130***a* or authenticator **130***b* may be based on the authenticator having the highest signal strength. Alternatively, or in addition, the mobile device may store a list of known addresses, and select an authenticator based on an address included in the responses from the authenticators. Mobile device **110** may draw charge according to the load pattern established with the selected authenticator (e.g., first authenticator **130***a*).

Although first authenticator **130***a* and second authenticator **130***b* are shown in the timing diagram of FIG. **4**, it is contemplated that more or fewer authenticators may be within operating range of mobile device **110** and each authenticator may send a response message and monitor for charge draw. In certain exemplary embodiments, the selection of the authenticator may be improper (i.e., mobile device **110** may choose an authenticator associated with an electric metering site not connected to mobile device **110**). FIG. **4** depicts a situation in which the mobile device **110** selects the second authenticator **130***b*, but it is connected to the power source associated with the first authenticator **130***a*. At step **450**, the authenticator which discovers a load draw after sending a response message to mobile device **110** (in this case authenticator **130***a*) may send a further response message to indicate to mobile device **110** that the authenticator has monitored a charge draw and also indicating the proper load pattern for the mobile device **110**. At step **460**, mobile device **110** may then determine the proper authenticator and draw charge according to the load pattern established with the proper authenticator.

At step **470**, based on the monitoring at step **420**, first authenticator **130***a* (as the selected authenticator) determines that mobile device **110** is drawing charge according to the load pattern indicated in the response message at step **420**. First authenticator **130***a* may send an acknowledgment of the pairing of mobile device **110** with first electric metering site **120***a* and may enable the initiation of a charge session for mobile device **110** based on the detected load pattern (e.g., when responsive to the load pattern being detected).

In certain embodiments the reselection of an authenticator may be eliminated if the load pattern is based on only the unique identification associated with mobile device **110**, such as a Mac address or other unique identifier.

Now referring to FIG. **5**, at step **510**, the charging system of mobile device **110** (e.g., a plug-in vehicle) may be prepared for charging. At step **520**, the mobile device's network interface (e.g., the plug-in vehicle's network interface card) may advertise to all authenticators (e.g., all meter network interface cards) stored in the mobile device's memory **117** (e.g., as a neighborhood table in memory **117**) the plug-in vehicle's intent to charge. At step **525**, the mobile device's network interface receives acknowledgement from the neighboring NICs in response to the advertisement, indicating their readiness to detect a message. At step **530**, the charging system **111** of plug-in vehicle **110** may initiate a series of loading following a pattern indicative of third party electrical loads. At step **540**, neighboring meter network interface cards that acknowledge vehicle advertisement monitor the load registers of their respective meters at a predetermined interval. For example, the sampling interval for load registers associated with meters that may be used for charging the plug-in vehicle's charging system may be increased from a normal sample range of about 30 seconds to about five minutes, to a faster range of about five seconds to about one minute, depending on the metering unit **126***a* used. At step **550**, the neighboring meter network interface card may determine whether to acknowledge the load pattern. Responsive to the neighboring meter network interface controller **132***a* acknowledging the load pattern of the third party load, at step **570**, the load pairing of first electric metering site **120***a* and plug-in vehicle **110** are verified using any of the previously disclosed authentication processes. At step **560**, if the neighboring meter network interface controller does not acknowledge the load pattern of the third party load, the monitoring of the load registers of the neighboring meter (e.g., meter unit **126***a*) may resume normal operations. For example, the sampling interval of the meter registers may be adjusted to a normal interval.

At step **575**, if the load pairing of the first electric metering site **120***a* and plug-in electric vehicle **110** is validated, the meter seal of the plug-in vehicle **110** is validated. At step **580**, if the load pairing is not verified at step **570**, the vehicle charging system is locked out. For example, the load switch **128***a* of first electric metering site **120***a* may be disconnected by meter network interface controller **132***a*. Further, if the meter seal of plug-in vehicle **110** is not validated, the vehicle charging system of plug-in vehicle **110** may be locked out at step **580**. If the meter seal of plug-in vehicle **110** is validated at step **575**, the back office determines whether the customer account associated with the plug-in vehicle is valid at step **585**. For example, the back office **150** may determine that the customer account has sufficient pre-paid funds or that a valid credit account is associated with the customer account. If the customer account is validated, the back office may send a charging commencement message to the meter network interface controller **132** to commence charging at step **590**. If the customer account is determined to be invalid by back office **150**, the back office may send an invalid account message to meter network interface controller **132***a* at step **580** to cause vehicle charging system of plug-in vehicle **110** to be locked out.

In another embodiment, the mobile device may first attempt to discover potential hosts within its communication range. Referring to FIG. **6**, at step **610**, mobile device **110** may broadcast a message to discover other communication nodes in operational range (e.g., one-hop nodes or neighboring nodes). For example, mobile device **110** may broadcast a message to first authenticator **130***a* and second authenticator **130***b*. Any neighboring node (authenticator) receiving the broadcast message directly from mobile device **110** may respond by sending a response message establishing the respective node (authenticator) as a neighboring or one-hop node. For example, at step **620**, first authenticator **130***a* may receive directly from mobile device **110** the broadcast message, and may reply with a response message indicating that authenticator **130***a* is a neighboring or one-hop node of mobile device **110**. This response may include instructions to initiate a general charge pattern. At step **630**, second authenticator **130***b* may receive the broadcast message directly from mobile device **110** and may send a response message with instructions to for a charge pattern, establishing second authenticator **130***b* as a neighboring or one-hop node as well.

Mobile device **110** may receive the response messages from the authenticators which neighbor the mobile device. At step **640**, the mobile device may send a message to the established neighboring nodes that mobile device **110** is initiating a series of current draws. In certain exemplary embodiments the current draws may be below a threshold level and/or may be a predetermined/fixed series of charge draws that are generic to third-party connections. At step **650**, mobile device **110** may initiate a series of charge draws according to the instructed pattern, and at steps **660** and **670** first authenticator **130***a* and second authenticator **130***b* may monitor for the series of charge draws, respectively. In the example of FIG. **6**, the mobile device is connected to the power source **122***a* associated with authenticator **130***a*. First authenticator **130***a*, upon detecting the current draw, may send an acknowledgment message instructing the mobile device to draw charge based on a unique, predetermined, specified, or negotiated load pattern and may monitor for charge draw according to the instructed load pattern, at step **680**. Mobile device **110** may receive the acknowledgment message and may draw charge according to the instructed load pattern, at step **690**. At step **695**, the authenticator may enable a charge session for mobile device **110** upon detection of the instructed load pattern and verification through the back office system.

From the foregoing, therefore, it can be seen that the disclosed embodiments provide techniques for associating and authenticating a mobile device with external power sources that can be used to charge the device. Communication between the mobile device and the power source is carried out via the manner in which the device draws power from the source. In some embodiments, wireless communication between the mobile device and the power source are used to enhance the capabilities for pairing the mobile device with the power source, and authenticating the device.

Once the pairing and authentication have been achieved, various approaches can be employed to quantify the amount of charge delivered to the mobile device. In one implementation, a standard rate of charge draw can be established for a given category of device. By measuring the duration of the charging period, the authenticator at the location of the power source can determine the amount of charge delivered, and report it to the back office **150**, for debiting the account of the device owner.

In another implementation, a sealed, tamper-proof meter can be installed in the mobile device and connected to its wireless network interface **112**. Once the pairing has been established, the authenticator or the back office can send a command via the network interface, to begin measuring the current draw, and report back, either during the transaction period or upon completion of the period.

If metering is possible at both the site of the source and within the mobile device, the charge amount measured at each location can be checked against one another for confirmation. In addition, the amount measured at the source can be employed to check the calibration, and/or detect tampering, of the meter in the mobile device.

Thus, it will be appreciated by those skilled in the art that the present invention can be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are therefore considered in all respects to be illustrative and not restricted. The scope of the invention is indicated by the appended claims rather than the foregoing description and all changes that come within the meaning and range and equivalence thereof are intended to be embraced therein.

What is claimed is:

1. A system for managing a charging session with a mobile device, comprising:

a mobile device; and

a wireless communication network comprised of a plurality of nodes, each node being associated with a charging device and configured to communicate between the associated charging device and the mobile device, wherein

the mobile device is configured to

send a broadcast message to one or more of the plurality of nodes in the wireless communication network requesting a charging session,

receive an instruction from one of the plurality of nodes in the network to initiate a unique load pattern associated with the mobile device, in response to the broadcast message, and

draw a charge in accordance with the unique load pattern corresponding to the received instruction.

2. The system of claim **1**, further comprising:

a plurality of charging devices, wherein each charging device is associated with a corresponding one of the plurality of nodes of the wireless communication network.

3. The system of claim **2**, wherein each charging device is configured to receive an authentication signal from the mobile device and respectively authenticate the mobile device based on the received authentication signal.

4. The system of claim **2**, wherein each charging device is configured to supply power to the mobile device from a power source based on the unique load pattern corresponding to the received instruction.

5. The system of claim **1**, wherein

the broadcast message includes an authentication signal,

each node of the plurality of nodes is configured to authenticate the mobile device using the authentication signal, and

the instruction is sent to the mobile device from the one of the plurality of nodes subsequent to authentication of the mobile device.

6. The system of claim **1**, further comprising:

a back office system configured to associate the charge drawn by the mobile device with an account associated with the mobile device.

7. A system for managing a charging session with a mobile device, comprising:

a mobile device; and

a wireless communication network comprised of a plurality of nodes, each node being associated with a charging device and configured to communicate between the associated charging device and the mobile device, wherein

the mobile device is configured to

send a broadcast message to one or more of the plurality of nodes in the wireless communication network requesting a charging session,

receive a corresponding instruction from at least two of the plurality of nodes in the wireless communication network to initiate a corresponding unique load pattern respectively associated with a corresponding one of the at least two nodes,

select one of the received instructions for execution, and

draw a charge in accordance with the unique load pattern corresponding to the selected instruction.

8. The system of claim **7**, further comprising:

a plurality of charging devices, wherein each charging device is associated with a corresponding one of the plurality of nodes of the wireless communication network.

9. The system of claim **8**, wherein each charging device is configured to receive an authentication signal from the mobile device and respectively authenticate the mobile device based on the received authentication signal.

10. The system of claim **8**, wherein each charging device is configured to supply power to the mobile device from a power source based on the unique load pattern corresponding to the received instruction.

11. The system of claim **7**, wherein

the broadcast message includes an authentication signal,

each node of the plurality of nodes is configured to authenticate the mobile device using the authentication signal, and

the corresponding instructions are sent to the mobile device from the at least two of the plurality of nodes subsequent to corresponding authentication of the mobile device by the at least two nodes, respectively.

12. The system of claim **7**, further comprising:

a back office system configured to associate the charge drawn by the mobile device with an account associated with the mobile device.

13. A method for managing a charging session with a mobile device, comprising:

sending, from a mobile device, a broadcast message requesting a charging session to at least one node among a plurality of nodes of a wireless communication network, wherein each node is associated with a charging device and is configured to communicate between the associated charging device and the mobile device;

receiving, by the mobile device, an instruction from one of the plurality of nodes in the network to initiate a unique load pattern associated with the mobile device, in response to the broadcast message; and

drawing a charge at the mobile device in accordance with the unique load pattern corresponding to the received instruction.

14. The method of claim **13**, wherein a plurality of charging devices are respectively associated with a corresponding one of the plurality of nodes, and

wherein the method comprises:

receiving, by each charging device associated with a corresponding one of the nodes, an authentication signal from the mobile device; and

authenticating, by each charging device, the mobile device based on the received authentication signal.

15. The method of claim **13**, wherein the charge drawn by the mobile device is supplied from the charging device associated with the one of the plurality of nodes.

16. The method of claim **13**, wherein

the broadcast message includes an authentication signal,

the plurality of nodes respectively authenticate the mobile device using the authentication signal, and

the instruction is sent to the mobile device from the one of the plurality of nodes subsequent to authentication of the mobile device.

17. The method of claim **13**, further comprising:

associating, by a back office system, the charge drawn by the mobile device with an account associated with the mobile device.

18. A method for managing a charging session with a mobile device, comprising:

sending, from a mobile device, a broadcast message requesting a charging session to at least one node among a plurality of nodes of a wireless communication network, wherein each node is associated with a charging device and is configured to communicate between the associated charging device and the mobile device;

receiving, by the mobile device, a corresponding instruction from at least two of the plurality of nodes in the network to initiate a corresponding unique load pattern respectively associated with a corresponding one of the at least two nodes;

selecting, by the mobile device, one of the received instructions for execution; and

drawing a charge at the mobile device in accordance with the unique load pattern corresponding to the selected instruction.

19. The method of claim **18**, further comprising:

receiving, by each charging device associated with a corresponding one of the nodes, an authentication signal from the mobile device; and

authenticating, by each charging device, the mobile device based on the received authentication signal.

20. The method of claim **18**, wherein the charge drawn by the mobile device is supplied from the charging device associated with the one of the plurality of nodes.

21. The method of claim **18**, wherein

the broadcast message includes an authentication signal,

the plurality of nodes respectively authenticate the mobile device using the authentication signal, and

the corresponding instructions are sent to the mobile device from the at least two of the plurality of nodes subsequent to corresponding authentication of the mobile device by the at least two nodes, respectively.

22. The method of claim **18**, further comprising:

associating, by a back office system, the charge drawn by the mobile device with an account associated with the mobile device.

23. A mobile device, comprising:

a network interface configured to establish a communication session with a wireless communication network comprised of a plurality of nodes, each node being associated with a charging device and configured to communicate between the associated charging device and the mobile device;

a transceiver configured to

send a broadcast message to one or more of the plurality of nodes in the wireless communication network requesting a charging session, and

receive an instruction from one of the plurality of nodes in the network to initiate a unique load pattern associated with the mobile device, in response to the broadcast message; and

a controller configured to draw a charge in accordance with the unique load pattern corresponding to the received instruction.

24. The mobile device of claim **23**, wherein

each charging device is associated with a corresponding one of the plurality of nodes of the network,

the transceiver is configured to transmit an authentication signal to the corresponding charging devices respectively associated with the plurality of nodes, and

the controller is configured to draw the charge in accordance with the unique load pattern from the charging device associated with the one of the plurality of nodes upon being authenticated by the charging device associated with the one of the plurality of nodes.

25. The mobile device of claim **23**, wherein the charge drawn by the controller of the mobile device is supplied by a charging device respectively associated with the one of the plurality of nodes and is based on the unique load pattern corresponding to the received instruction.

26. The mobile device of claim **23**, wherein

the broadcast message includes an authentication signal,

the plurality of nodes are configured to respectively authenticate the mobile device using the authentication signal, and

the instruction is sent to the mobile device from the one of the plurality of nodes subsequent to authentication of the mobile device.

27. The mobile device of claim **23**, wherein a back office system connected to the network is configured to associate the charge drawn by the controller of the mobile device with an account associated with the mobile device.

28. A mobile device, comprising:

a network interface configured to establish a communication session with a wireless communication network comprised of a plurality of nodes, each node being associated with a charging device and configured to communicate between the associated charging device and the mobile device;

a transceiver configured to

send a broadcast message to one or more of the plurality of nodes in the wireless communication network requesting a charging session, and

receive a corresponding instruction from at least two of the plurality of nodes in the wireless communication network to initiate a corresponding unique load pattern respectively associated with a corresponding one of the at least two nodes; and

a controller configured to

select one of the received instructions for execution, and

draw a charge in accordance with the unique load pattern corresponding to the selected instruction.

29. The mobile device of claim **28**, wherein

each charging device is associated with a corresponding one of the plurality of nodes of the network,

the transceiver is configured to transmit an authentication signal to the corresponding charging devices respectively associated with the plurality of nodes, and

the controller is configured to draw the charge in accordance with the unique load pattern corresponding to the selected instruction from the charging device associated with one of the plurality of nodes from which the selected instruction was received, upon being authenticated by the charging device associated with the one of the plurality of nodes.

30. The mobile device of claim **28**, wherein the charge drawn by the controller of the mobile device is supplied by a charging device respectively associated with one of the plurality of nodes from which the selected instruction was received, and the charge drawn by the controller is based on the unique load pattern corresponding to the received instruction.

31. The mobile device of claim **28**, wherein

the broadcast message includes an authentication signal,

each node of the plurality of nodes is configured to authenticate the mobile device using the authentication signal, and

the instruction is sent to the mobile device from the one of the plurality of nodes subsequent to the authentication of the mobile device.

32. The mobile device of claim **28**, wherein a back office system of the network is configured to associate the charge drawn by the controller of the mobile device with an account associated with the mobile device.

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